

CHAPTER 27

SOILS INVESTIGATIONS

27.1 General

27.1.1 General Requirements

There are four categories of testing and reports required for all projects. They are:

- **Geotechnical Report** - This report evaluates the general issues of groundwater, soil stability, and swell potential. If groundwater is found within certain parameters, a subsurface water investigation is required. A geotechnical report is required for street and related improvements within the ROW, public easements, or slope easements.
- **Final Pavement Design Report** - This report is required for all projects with roadway improvements. The soil investigation associated with this report will occur after grading for roadways and utilities is complete. This report must be submitted and approved prior to any nonstructural concrete or paving installation.
- **Extra Testing** - If fill material is required for the project, this material shall also be tested before placement.
- **Supervision by Engineer** - All sampling and testing of soils shall be performed under the direct supervision of a Professional Engineer who stamps the report.

27.2 Soil Testing

27.2.1 Timing of Soil Borings

- **Initial Borings** - The information from the initial soil borings must be summarized in the geotechnical report. The entire site shall be sampled for initial testing. This is required because street locations may not yet be determined or may change.
- **Structures** - Soil borings for design of structures shall be taken prior to the design of the structure.
- **Imported Fill for ROW Grading** - All fill material shall be approved by the District prior to its use on the project. The material should meet minimum DDOT requirements and be equal to or better than existing conditions.

27.2.2 Frequency of Testing

- **Basic Requirements** - A minimum of two borings shall be provided for each project. The number of borings should be dependent on project

size and geotechnical Engineer's recommendations. The District Project Manager may require more frequent testing.

- Structures - Testing frequency for structures shall satisfy **AASHTO Bridge Design** requirements and materials testing requirements.

27.2.3 Location of Samples

- Basic Requirements - Samples shall be taken to a minimum depth of 10 ft. below the finished grades or as directed.
- Groundwater or Bedrock - Borings shall extend deeper if needed to determine if bedrock or high groundwater levels are design concerns. Minimum depth to bedrock shall be 3 ft. below the finished pavement surface.
- Number of Samples - Use standard care in determining the number of samples that are needed to characterize soils.
- Structures - Samples for structures shall be taken to a minimum depth of 10 ft. below the footing elevation. Additional depth may be required for piers or piles.

27.3 Soil Grouping

27.3.1 General

To simplify sub-grade support testing, soil samples may be combined to form soil groups consistent with the **AASHTO** classification, group index, and location for the area investigated. Groupings shall not mix samples with different **AASHTO** classifications. (For example, soils with swell potential greater than 2 percent may not be grouped).

27.3.2 Composite Samples

- Composite Samples - Composite samples may be obtained by mixing portions of each sample within a soil group to provide a uniform sample of the soil group.
- Specific Tests for Composite Samples - Composite samples shall be classified using the methods described in this manual. Composite samples remolded in the laboratory shall not be used for swell/consolidation testing.

27.4 Testing

27.4.1 Required Tests

The tests shown in Table 27-A are required for the sub-grade soils investigations or final pavement design testing.

Table 27-A:
Required Tests

TEST	GEOTECHNICAL REPORT	FINAL PAVEMENT DESIGN REPORT
Visual	X	X
Liquid Limit	X	X
Plastic Limit	X	X
Moisture	X	X
percent Passing 200	X	X
Gradation (Granular Soils)	X	X
AASHTO Classification	X	X
Sub-grade Support		
R-Value		X
Swell Evaluation (Preliminary Considerations)	Indicator: Low/Moderate/High For Moderate or High, Run Swell Tests	Mitigation and Detailed Analysis
Percentage of Soluble Sulfates	X	X
Standard Penetration Test	X	X
Groundwater	X	X
Bedrock Level	X	X
Corrosion Potential Resistivity	X	

27.4.2 Classification Testing

Soils shall be classified visually and tested to determine the properties listed within this chapter. Sands and gravel samples shall be analyzed for gradation where needed to comply with classification requirements.

27.4.3 Subsurface Explorations

27.4.3.1 General

- Required borings shall be located on the plan of the structure by station and offset from the base line. Five copies of the print shall be enclosed with the memorandum of transmittal. Request for borings shall be made as early as possible in the preliminary design stage.
- At least two borings shall be made for each bridge substructure unit. For long retaining walls and culverts, borings should be spaced not less than 50 ft. to, not greater than 100 ft. apart. One boring shall be provided at each footing location for both

overhead and cantilever sign structures and high-level light tower foundations.

- Where piles are anticipated, depths of borings shall be determined accordingly. The borings shall be deeper than any anticipated pile lengths.
- Location of borings and identification numbers shall be shown both on preliminary and final General Plan and Elevation sheets for each bridge and structure.
- Subsurface soil profiles and boring log information shall not be shown on the contract plans.

27.4.4 Boring Log Form

Use Standard Department Form

27.4.5 Sub-grade Support Testing

Individual sub-grade or composite samples shall be tested for sub-grade support value. The geotechnical report shall clearly state whether the sub-grade soil is capable of supporting the proposed construction and design traffic loads. Recommendation for sub-grade stabilization, if required, shall also be provided. The final pavement report shall contain specific mitigation.

27.4.6 ROW Fill Material Testing

- Test Prior to Use - All imported fill material shall be tested for swell and R-value and approved by the District Project Manager prior to use in the ROW.
- R-value and Plasticity Index - All imported fill shall have an R-value and plasticity index equal to or greater than the sub-grade material within the ROW.
- Expansion Potential - All imported fill shall not have a liquid limit greater than 40 and plasticity index greater than 20.

27.5 Geotechnical Report

27.5.1 Basic Report Requirements

The report shall show results from all required testing in Table 27-A. The report shall also include a description of site characteristics, e.g., topography, drainage features, etc.

27.5.2 Detailed Report Requirements

In addition to the basic report requirements, each soils report shall include the following items:

- Site location and description
- Laboratory test reports with evaluations (classification tests)
 - Visual classification
 - Liquid limit - **AASHTO T89 or ASTM D4318**
 - Plastic limit - **AASHTO T90 or ASTM D4318**
 - In-site moisture content
 - Percent passing No. 200 sieve - **AASHTO T11 or ASTM C117-90**
 - Gradation of granular (sand & gravel) materials - **AASHTO T27, ASTM D422 or ASTM C136**
 - **AASHTO** classification and group index - **AASHTO M145**
 - Standard Penetrations Test
 - Swell Evaluation
- Boring logs
- Soil and groundwater conditions - The expected seasonal elevation variation shall be summarized.
- Depth to bedrock - To indicate shallow bedrock
- Include mitigation requirements if bedrock is within 3 ft. of sub-grade
- Percentage of soluble sulfates.
- Recommendations and discussions
- Mitigation plans
- Additional tests - These may be required for trench backfill evaluation, fill evaluation, etc.
- Elevation of groundwater encountered in each boring
- Engineer seal and signature – Required

27.6 Surface Water Investigation

27.6.1 When a Subsurface Water Investigation is Required

- Criteria - If groundwater is encountered within 5 ft. of the original ground surface, a subsurface water investigation report shall be submitted for approval by the District Project Manager. This report is required to ensure mitigation of high groundwater effects upon public improvements within the ROW. This information may be a separate report or may be included in the geotechnical report.
- Requirement Waiver - This report requirement may be waived if the Applicant and Designer certify that the street sub-grade elevations will be a minimum of 3 ft. above the “maximum” predicted (seasonal highest) water table.

- Exception for Buried Utility Construction - This report is not required for temporary de-watering activity needed to facilitate construction of buried utilities.

27.6.2 Report Requirements

The subsurface water investigation report shall include the following information:

- Site location and description. Include locations of any irrigation ditches
- Elevation of water table, direction of flow, and flow rates
- Potential sources of groundwater. Include proximity to irrigation ditch systems
- Other relevant subsurface information
- Potential future groundwater conditions
- Subsurface drainage recommendations
- Cone of influence
- Control measures and designs
 - Subsurface Drains - If subsurface drains are recommended, the drains must have a gravity discharge without any possibility of back flow. Any subsurface drain system shall be owned and maintained by the Consultant or the Consultant's assigned successor(s). These drains may discharge into the District's storm drainage system, including inlets or detention ponds, upon approval of the District Project Manager and WASA. Anticipated impacts to the round water table on adjacent properties must be quantified.
 - Drain Lines - The drain lines may be installed in the sanitary sewer trench, at an elevation of one sewer diameter lower than the sanitary sewer line.
 - Drain Line Separation from Sewer - The drain line shall be marked to specifically distinguish the drain from the sanitary sewer line.
 - Pipe - The drain line shall be an approved material pipe, with appropriate clean-outs.
 - Drain Outlet - The outlet of the drain into an inlet structure or detention pond shall be designed to prevent any possibility of back flow and blockage of the drain line.
- Professional Engineer's seal and signature.

27.7 Soil Problem Mitigation

Mitigation plans for soil problems revealed by the soils investigation shall address the following specific factors in the sections to follow.

27.7.1 Mitigation Plans and Approval

All special problems found in soils investigation (e.g., expansion, frost, soluble sulfates, shallow bedrock, heave, groundwater, soil instability, utility backfill, etc.) shall be addressed in the mitigation plans. Prior to implementation, all mitigation procedures must be approved by the District Project Manager.

27.7.2 Mitigation for Swell

If the average swell is 2 percent or greater, the pavement design report must provide mitigation measures. The mitigation measures shall reduce destructive swell potential to an acceptable level of less than 2 percent. The swell test report shall specify sample conditions, surcharge pressures, and other key testing factors.

27.7.3 Examples of Swell Mitigation

Examples of mitigation include the following:

- Over-Excavation - Over-excavation and replacement with suitable non-expansive or low-expansive material to a depth sufficient to mitigate expansion is a common mitigation method.
- Chemical Treatment - Chemical treatment may be used to mitigate expansive characteristics of the soil.
- Sub-drains - Sub-drains may be effective at reducing the groundwater, thereby reducing swelling. However, sub-drains will be subject to all of the subsurface drain requirements in these Standards.
- Moisture Treatments - Condition with moisture and compact to an appropriate level of compaction for the expansive condition, including stability requirements.
- Other Procedures - Other procedures may be proposed for review and approval by the District Project Manager.

27.7.4 Mitigation of Unstable Sub-grade (Examples)

- Over-Excavation - Over-excavation and replacement with suitable non-expansive material to a depth sufficient to stabilize the sub-grade is a common mitigation method.
- Chemical Treatment - Chemical treatment to eliminate unstable characteristics of the soil is another common mitigation method.
- Other Procedures - Other procedures may be proposed for review and approval by the District Project Manager.

27.7.5 Specific Mitigation Requirements

- **Extent of Mitigation** - Moisture treatment alone may not be sufficient. If expansive soil mitigation is made, the soil treatment shall extend to the back of curb, or to the back of walk for attached or monolithic walk. For detached walk, separate mitigation procedures may be required.
- **Approval of Chemical Treatment** - Mitigation procedures that alter existing soil conditions (such as lime, fly ash, or cement treatment) shall follow an approved mix design process. Additional testing is required to verify that no swell is introduced in the chemical treatment.